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Gender Differences in Level and Change in Cognitive Functioning

Results from the Longitudinal Aging Study Amsterdam

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Key Words

Gender · Age · Cognitive abilities · Latent change models

Abstract

Background: Gender differences in level of cognitive functioning are frequently observed, but little is known about gender differences in rate of decline of cognitive functioning. **Objective:** The present study aims to describe variability between and within men and women specified for four different cognitive abilities at baseline, and variability in change in these abilities among men and women over 6 years. **Methods:** We started with a study sample of 1,132 men and 1,175 women, with a measurement interval of 3 years. At wave 3 of the study, 1,552 of the respondents from wave 1 were still present. Differences in level and rate of change were estimated with latent change models. **Results:** Women have higher levels of memory functioning than men, but no gender differences were observed for speed or non-verbal reasoning changes. **Conclusion:** In spite of evidence for a stronger age-related atrophy of the brain structure of men, no gender differences in decline of cognitive functions could be observed.

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Introduction

A classical question in research on cognitive ageing is how cognitive functions change within an individual over age and time, and whether these patterns are different from one variable to another [1]. The theory of fluid and crystallized intelligence [2] proposes that cognitive abilities such as non-verbal reasoning, memory, and processing speed – also referred to as fluid intelligence – decline with ageing, whereas acculturated knowledge – also referred to as crystallized intelligence – increases with ageing. Studies evaluating these predictions observe major inter- and intraindividual differences in cognitive functioning [1, 3].

One of the variables possibly accounting for inter- and intraindividual differences in fluid intelligence is gender. Evidence for gender differences in level of functioning comes from a study on the structure of the brain, in which a more pronounced atrophy with advancing age in males than in females [4] was observed, suggesting that women are less vulnerable to age-related changes in cognitive abilities than men. Also studies on the function of the brain observed gender-related differences in level of cognitive functioning. In those studies, women outperform men with respect to memory functioning [5] and speed [6] and men show better results on spatial abilities [6] and reasoning [7]. Based on significant interactions between

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age and gender, men show less decline in speed and reasoning than women [6].

However, to evaluate intraindividual variability in cognitive functioning and whether men and women differ in rate of change, longitudinal data are needed. There are a few studies that focused on gender differences in rate of change, but results are inconclusive. Larrabee and Crook [8] observed that women showed less rapid decline in delayed recall than men, whereas Finkel et al. [9] did not observe gender differences in rate of change.

The main aim of the present longitudinal study is to evaluate inter- and intraindividual variability in fluid intelligence. More precisely, we describe differences in level of fluid intelligence between men and women specified for immediate and delayed recall, information processing speed and non-verbal reasoning, and whether men and women differ in rate of decline during the study period. We control for level of education as men, on average, are higher educated than women. Although the level of education is an important predictor of crystallized intelligence, due to the interrelationship with fluid intelligence [2] it may also affect fluid intelligence.

Method

Sample

Data are derived from the Longitudinal Aging Study Amsterdam (LASA), which is an ongoing longitudinal, multidisciplinary research project focusing on autonomy and well-being in the ageing population [10]. The general design, measures, and procedures of LASA have been described elsewhere [10, 11]. For the present study we selected respondents who were at least 60 years old at baseline, as the youngest birth cohort (i.e., aged between 55 and 59) was excluded for the assessment of memory and speed at follow-up. We further excluded respondents who might have been suffering from dementia at baseline (23 or lower on the MMSE). Although it can be argued that people at risk of dementia are an integral part of ageing as a population process [7], we decided to exclude them because of the differences in rate of cognitive decline between demented and non-demented individuals [12]. Thus, the study sample consisted of 1,132 men and 1,175 women (74% of total sample) at baseline.

Attrition ($n = 755$) between T_1 and T_3 was caused by mortality (560 persons, 75%), refusal (115 persons, 15%), frailty (62 persons, 8%), and failure to contact (18 persons, 2%). Attrition is associated with all variables included in the analysis; lower scores on immediate recall (-1.0 word on 15 Words Test) and delayed recall (-1.2 word on 15 Words Test), lower speed (-4 letter-letter combinations per trial of 1 min), lower scores on non-verbal reasoning (-1.7 on a 24-point scale) being male, and high age (5 years older) (all $p < 0.001$) at T_1 .

Measures

Cognitive Variables. The cognitive abilities in this study were aspects of fluid intelligence, i.e., immediate recall, delayed recall, non-verbal reasoning and information processing speed. The 15-

Words Test [13], derived from the Auditory Verbal Learning Test [14], was chosen for the assessment of immediate and delayed recall. Raven's Coloured Progressive Matrices [15] was used to measure non-verbal reasoning. An adaptation of the Coding Task [unpubl. data] was used to assess information processing speed.

Confounding Variables. Level of education was assessed by asking the respondent for the highest educational course completed, resulting in a variable ranging from 1 (incomplete elementary education) to 9 (university education). Age is presented in years.

Procedure. Latent change models [16] were used to estimate the level and rate of change in the four cognitive functions. With this type of modelling, it is possible to estimate individuals' true levels of cognitive functioning (level), true rates of linear (slope) and non-linear (e.g. quadratic slope) change, as well as the individual variability in test performance separately for men and women. The factor loadings were constrained to be equal across time (factorial invariance). No residual covariances, indicating that errors within or between measurements are correlated, were included. For the one-indicator models (i.e. delayed recall and non-verbal reasoning), we further constrained the error variances of the indicators to be equal across time (homoscedasticity) in order to have a positive number of degrees of freedom. When good fitting models were obtained (i.e. CFI > 0.95 , RMSEA < 0.06 , SRMR < 0.08 [17]), potential predictors of level and change, i.e., age and level of education, were included. The latent change models were estimated with Mplus 2.1 [17].

As a higher dropout rate was related to all study variables (see sample description), missing values in our study sample could not be considered missing completely at random (MCAR). If they were, then a listwise deletion of observations with missingness on any of the variables would not affect the parameter estimates [18]. If observations are missing at random (MAR), which is the case when probabilities of values being missing can be predicted by variables that are not missing [17], then a better approach is to use incomplete data and estimate all missing values based on observation on the variables that are not missing. Mplus performs maximum-likelihood estimation under MAR.

Results

Two estimated parameters are of particular interest, i.e. level and slope, and in the case of non-linear change, quadratic slope [2]. The estimated levels and slopes for the four cognitive abilities are estimated separately for men and women (table 1). The levels describe the true level of cognitive functioning, adjusted for age and level of education. The slopes describe the annual rate of change during the time in study, adjusted for age and level of education.

All models fitted the data moderately (delayed recall) to excellent (non-verbal reasoning). The 95% confidence intervals (CIs) indicate whether the parameters significantly differ from zero (zero not included in the CIs), or whether parameters differ significantly from each other (no overlap in CIs). According to the levels and the accompanying CIs, it appeared that women had higher levels of immediate recall ($+0.50$) and delayed recall than

Table 1. Latent level and slope of immediate recall, delayed recall, information processing speed, and non-verbal reasoning adjusted for age and level of education, by gender

Cognitive ability		Parameter	Men	95% CI		Women	95% CI		Fit statistics				
				LL	UL		LL	UL	χ^2	d.f.	CFI	RMSEA	SRMR
Immediate recall	M	level	4.09	4.01	4.20	4.59	4.52	4.71	(men)				
		slope	0.26	0.18	0.34	0.23	0.13	0.29	97.87	34	0.99	0.04	0.04
		slope ²	-0.20	-0.25	-0.14	-0.19	-0.22	-0.11	(women)				
	Var	level	1.32	1.07	1.56	1.36	1.10	1.61	89.90	34	0.99	0.04	0.04
		slope	0.02	0.01	0.03	0.01	0.00	0.02					
Delayed recall	M	level	4.28	4.15	4.46	5.53	5.40	5.74	(men)				
		slope	0.59	0.42	0.74	0.74	0.52	0.86	12.46	2	0.98	0.07	0.05
		slope ²	-0.44	-0.53	-0.32	-0.53	-0.61	-0.39	(women)				
	Var	level	3.57	3.01	4.21	4.53	3.87	5.34	16.11	2	0.98	0.08	0.07
		slope	0.02	-0.01	0.05	0.04	0.01	0.07					
Information processing speed	M	level	21.74	21.44	22.26	22.03	21.76	22.60	(men)				
		slope	-0.36	-0.39	-0.29	-0.30	-0.33	-0.24	130.50	35	0.99	0.05	0.03
	Var	level	38.10	33.68	42.63	42.57	38.57	47.93	(women)				
		slope	0.17	-0.00	0.34	0.16	0.06	0.38	125.08	35	0.99	0.05	0.04
Non-verbal reasoning	M	level	17.95	17.71	18.18	17.59	17.37	17.82	(men)				
		slope	-0.20	-0.21	-0.12	-0.17	-0.21	-0.13	3.32	3	1.00	0.01	0.01
	Var	level	11.00	9.63	12.36	9.62	8.27	10.97	(women)				
		slope	0.05	0.00	0.10	0.00	-0.05	0.05	3.64	3	1.00	0.01	0.02

Significant effects appear in bold, significant differences between men and women in bold and italic (n men = 1,132, n women = 1,175).

M = Mean; Var = variance; LL = lower level; UL = upper level; d.f. = degrees of freedom; CFI = comparative fit index; RMSEA = root mean square error of approximation; SRMR = standardized root mean square residual.

men (+1.25). Differences between men and women in level of information processing speed and non-verbal reasoning were not significant. The variances of the estimated levels indicate substantial interindividual variability in level of functioning within men and women.

The estimated slopes provide information on the annual rate of change. As quadratic slopes make a visual evaluation rather complicated, we calculated the average total amount of change over 6 years in the four cognitive abilities separately for men and women. There was significant linear and non-linear decline in immediate recall (total decline: -0.24 for men, and -0.33 for women) and delayed recall (total decline: -0.42 for men, and -0.33 for women), and significant linear decline in information processing speed (total decline: -2.16 for men, and -1.80 for women) and non-verbal reasoning (total decline: -1.20 for men, and -1.02 for women). Gender differences in rate of decline did not reach the level of significance for any of the cognitive abilities. The non-significant variances of the slope parameters indicate that the rate of change within men and women was almost the same for all individuals.

Discussion

In the present study we described inter- and intraindividual differences in level and rate of change of fluid intelligence, adjusted for age and level of education. Our study revealed that women had higher scores on immediate recall and substantially higher on delayed recall. No gender differences in information processing speed and non-verbal reasoning were observed. Also the rate of cognitive decline was not significantly different for men and women.

The non-linear decline in immediate and delayed recall may be due to an improvement in functioning at T₂. This improvement is often interpreted as a practice effect. In many tests involving learning practice effects can be observed [19]. Practice effects may have been due to the fact that respondents have remembered the delayed recall test, for which they were unprepared at the first measurement cycle. They may therefore have listened more carefully to the words during the third measurement, which resulted in a better overall score.

The finding that women outperform men with respect to immediate and delayed recall is in line with previous research [5]. In contrast to other studies [6, 7], no gender differences were found in speed and non-verbal reasoning. Based on studies on the structure of the brain [4], stronger declines in fluid abilities for men were to be expected. On the contrary, based on studies on the function of the brain [6], stronger declines for women were to be expected. However, none of the findings on gender differences in cognitive decline could be replicated.

Possible reasons for the differences in study results may relate to the differences in methods. First of all, our study results are based on longitudinal data, whereas for the other studies cross-sectional data were used. Cross-sectional studies confound age changes with cohort differences [20]. Apparently, the earlier born cohorts are in less favourable positions than the later-born cohorts, which explains that older people cross-sectionally have lower scores on cognitive tests than younger people. With longitudinal data it is possible to unravel age from cohort effects. Second, with latent change models it is possible to distinguish true change from observed change, by taking into account the effect of measurement errors. When mea-

surement errors are present, it is possible that part of the observed change must be attributed to measurement error rather than to true change. Finally, in the latent change models missing values were replaced by estimates based on the remaining observations, which may reduce the biasing influence of attrition.

To conclude, our study revealed that, on average, the level of fluid intelligence decreases at age 60 and over. We further revealed that women had higher levels on immediate and delayed recall than men, and that there are rather substantial individual differences in level of functioning. Furthermore, in spite of evidence for a stronger age-related atrophy of the brain structure of men, no gender differences in decline of cognitive functions could be observed and interindividual differences in rate of cognitive change are small.

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References

- McArdle JJ, Ferrer-Caja E, Hamagami F, Woodcock RM: Comparative longitudinal structural analyses of the growth and decline of multiple intellectual abilities over the life span. *Dev Psychol* 2002;38:115–142.
- Horn JL, Cattell RB: Age differences in fluid and crystallized intelligence. *Acta Psychol* 1969;26:107–129.
- Christensen H, Mackinnon AJ, Korten AE, Jorm AF, Henderson AS, Jacomb B, Rodgers B: An analysis of diversity in cognitive performance of elderly community dwellers: Individual differences in change scores as a function of age. *Psychol Aging* 1999;14:365–379.
- Gur RC, Mozley PD, Resnick SM, Gottlieb GL, Kohn M, Zimmerman R, Herman G, Atlas S, Grossman R, Berretta D, Erwin R, Gur RE: Gender differences in age effect on brain atrophy measured by magnetic-resonance-imaging. *Proc Natl Acad Sci USA* 1991;7:2845–2849.
- Zelinski EM, Gilewski MJ, Schaie KW: Individual differences in cross-sectional and 3-year longitudinal memory performance across the adult life span. *Psychol Aging* 1993;8:176–186.
- Meinz EJ, Salthouse TA: Is age kinder to females than to males? *Psychonom Bull Rev* 1998;5:56–70.
- Lindenberger U, Baltes PB: Intellectual functioning in old and very old age: Cross-sectional results from the Berlin Aging Study. *Psychol Aging* 1997;12:410–432.
- Larrabee GJ, Crook TC: Do men show more rapid age-associated decline in simulated everyday verbal memory than do women? *Psychol Aging* 1993;8:68–71.
- Finkel D, Reynolds CA, McArdle JJ, Gatz M, Pedersen N: Latent growth curve analyses of accelerating decline in cognitive abilities in late adulthood. *Dev Psychol* 2003;39:535–550.
- Deeg DJH, Knipscheer CPM, Van Tilburg W: Autonomy and Well-Being in the Aging Population: Concepts and Design of the Longitudinal Aging Study Amsterdam. Bunnik, Netherlands Institute for Gerontology, 1993.
- Aartsen MJ, Smits CHM, Van Tilburg TG, Knipscheer CPM, Deeg DJH: Activity in older adults: Cause or consequence of cognitive functioning? A longitudinal study on everyday activities and cognitive performance in older adults. *J Gerontol* 2002;57B:153–162.
- Reynolds CA, Gatz M, Pedersen NL: Individual variation for cognitive decline: Quantitative methods for describing patterns of change. *Psychol Aging* 2002;17:271–287.
- Saan RJ, Deelman BG: Nieuwe 15-woorden test A en B (15WTA en 15WTB) [new version of 15 words test (15WTA and 15WTB)]; in Bauma A, Mulder J, Lindeboom J (eds): *Neuro-psychologische diagnostiek. Handboek. [Neuro-psychological diagnostics. Handbook]*. Amsterdam, Swets & Zeitlinger, 1986, pp 13–28.
- Rey A: *L'examen clinique en psychologie [The clinical examination in psychology]*. Paris, Presse Universitaire de France, 1964.
- Raven J, Raven JC, Court JH: *Raven Manual: Selection 1. General Overview*. Oxford, Psychologist Press, 1995.
- Willett JB, Sayer AG: Using covariance structure analysis to detect correlates and predictors of individual change over time. *Psychol Bull* 1994;116:363–381.
- Muthén B, Muthén L: *Mplus (Version 2.1) [Computer software]*, 2001.
- Enders CK: *A primer on maximum likelihood algorithms available for use with missing data. Structural Equation Modeling* 2001;8:128–141.
- Lezak MD: *Neuropsychological Assessment*, ed 3. New York, Oxford University Press, 1995.
- Schaie KW: *A general model for the study of developmental problems. Psychol Bull* 1965;64:92–107.